

Polar aerosol chemical characterization. A ten-year Italian experience.

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The aerosol plays a key role in the complex feedback processes between climate forcings and environmental responses, through the interaction with the solar irradiation (scattering and absorption processes) and as CCN sources. 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. In order to improve our knowledge on the atmospheric load and chemical composition of Polar aerosol, several measurements and sampling campaigns were carried out both in Antarctica and in the Arctic since 2005.

In order to understand the main atmospheric processes possibly leading anthropogenic and natural aerosol components in inner Antarctica, a continuous all-year-round sampling of size-segregated aerosol were carried from 2005 to 2013 at Dome C (East Antarctica; 75° 60' S, 123° 200' E, 3220 m a.s.l. and 1100 km away from the nearest coast).

Aerosol was collected by PM10 and PM2.5 samplers and by multi-stage impactors (4 stages: < 1.0, 1.0-2.5, 2.5-10, > 10 ; 8-stages from 0.7 to 10 μm). Chemical analysis was carried out by Ion Chromatography (ions composition) and ICP-MS (trace metals).

Sea spray showed a sharp seasonal pattern, with winter (Apr-Nov) concentrations about ten times larger than summer (Dec-Mar). Besides, in winter, sea spray particles are mainly sub micrometric, while the summer size-mode is around 1-2 μm . Meteorological analysis on a synoptic scale and air mass back trajectory reconstructions allowed the identification of two major air mass pathways, reflecting different size distributions: micrometric fractions for transport from the closer Indian-Pacific sector, and sub-micrometric particles for longer trajectories over the Antarctic Plateau.

Methanesulphonic acid (MSA) and non-sea-salt sulphate (NssSO_4^{2-}) were chosen as markers of oceanic biogenic emission (as end-products of the atmospheric oxidation of dimethylsulphide). The two species exhibit a seasonal cycle with summer maxima (Nov-Mar). NssSO_4^{2-} and MSA size distributions show two modes (0.4- 0.7 μm and 1.1-2.1 μm) in early summer and just one sub-micrometric mode in full summer. The two modes are related to different transport pathways from oceanic areas to the central Antarctic Plateau. In early summer, air masses came primarily from the Indian

Ocean and spent a long time over the continent. The transport of sulphur compounds is related to sea spray aerosols and the resulting condensation of H_2SO_4 and MSA over sea salt particles form sodium salts. Conversely, in mid-summer, a rapid transport of H_2SO_4 and MSA formed above the boundary layer over oceanic areas leads to higher concentrations of the acidic species in the fine fraction of aerosols reaching Dome C.

Non-sea-salt calcium was used as a continental dust marker. Besides the seasonal pattern, single dust inputs were observed. A large transport event of dust coming from Patagonia was studied with a combined and complementary use of satellite retrievals, transport model simulation and surface observations.

In the Arctic, a continuous all-year-round PM10 sampling campaign is ongoing since 2010 at Thule (North Greenland). 24-h samples are continuous collected at daily or every other day resolution. Contemporaneously, "summer" (March to September) aerosol was annually collected at Ny Alesund (Svalbard Islands, Norway; 78°56' N, 11°56'E; 50 m a.s.l.). 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, in order to study the effect of the PBL dynamics on the aerosol atmospheric load and chemical composition.

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 – 20 μm ; 10 min resolution) and Black Carbon (by Particle Soot Absorption Photometry – PSAP) were carried out during the sampling periods.

Specific chemical markers (such as REEs elements for dust, MSA for biogenic emissions, selected heavy metals for local and long-range anthropic sources), Positive Matrix Factorization (PMF) statistical analysis and Back-Trajectory Cluster Analysis were used in order to identify possible aerosol source areas and to evaluate reliable source apportionment. The most relevant results are here shown.