Arctic Aerosol at the Svalbard Island in Year 2010. Modal Structure, Elemental Composition and Time Dependence of the Crustal Aerosol Component

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INTRODUCTION

A multiannual, multipurpose experiment on atmospheric properties (Dirigibile Italia) is being carried on at the Svalbard Islands, starting in year 2010. Major reasons of interest, both climatic and chemical, concerning the study of atmospheric aerosol were explained in the 2011 LNL Annual Report, together with basic experimental features and some preliminary results. Here we present some results concerning the crustal aerosol component during the 2010 campaign. This component has a crucial climatic interest due to its interaction with radiation.

We remind that 43 samples were collected, with an SDI 12-stage impactor during the period March, 15^{TH}-September, 9^{TH}, 2010, with a 4-days sampling time. Each sample is composed by 12 size-segregated subsamples, each one characterized by a well-defined value of the mean aerosol aerodynamic diameter. All subsamples were PIXE measured and the aerosol Elemental Mass Distributions, EMSD's, ng m^{-3}, were obtained for 12 elements, when detected. Here we consider the EMSD's of four purely crustal elements: Al, Si, Fe and Ti.

SIZE MODES

In almost all cases, a lognormal representation of the EMSD's of element Si was possible with, at most, three size modes: supermicrometric, submicrometric and an intermediate mode around 1 µm. Three parameters characterize each mode: mean aerodynamic diameter, X_0; width W; intensity A, ng m^{-3}. A further "level" parameter, y_0, is required in the fit. Due to higher detection limits, a smaller number of modes is detected for element Al, Fe and Ti.

Figure 1 presents two examples of quite different situations: the EMSD's of elements Si (figure 1a) and, respectively, Fe (figure 1b) in sample GB08 display relatively similar shapes, whereas the corresponding shapes for sample GB07, figures 1c and 1d, are very different.

ELEMENTAL COMPOSITION

Composition varies with both sample number and size mode. Its knowledge is relevant in determining both aerosol origin and the extent of its interaction with radiation.

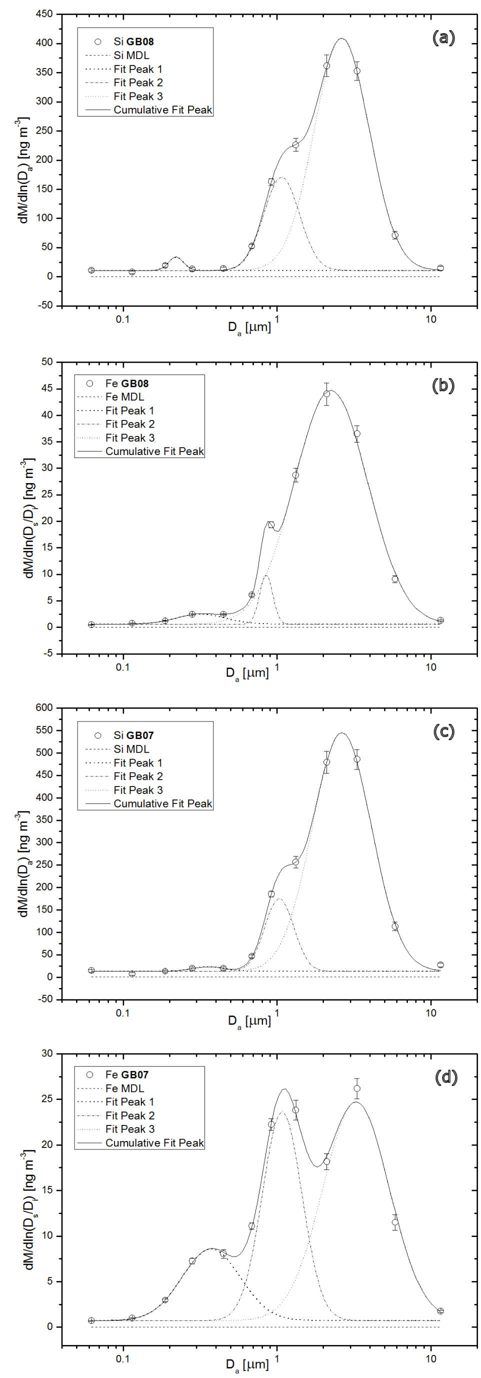

Fig. 1. Elemental Mass Size Distributions of elements Si and Fe in samples GB08 and GB07.

This second aspect is the most important one in the present experiment and therefore we focus our attention over a set of (10) contiguous samples (GB04 to GB13) which include a full continuous episode of very high Si concentration values (with the exception of the initial sample GB03).

We first consider the example of sample GB08. Figure 2 displays the scatterplot of the concentration, ng•m^{-3}, of Fe vs that of Si, for the 12 SDI stages. A straight line fits the data and its slope measures the Fe/Si concentration ratio over the full detected size range. Analogous results are obtained by fitting the scatterplots of Al vs Si and of Ti vs Si. The composition of sample GB08, for elements Al, Si, Fe and Ti is obtained in this way.

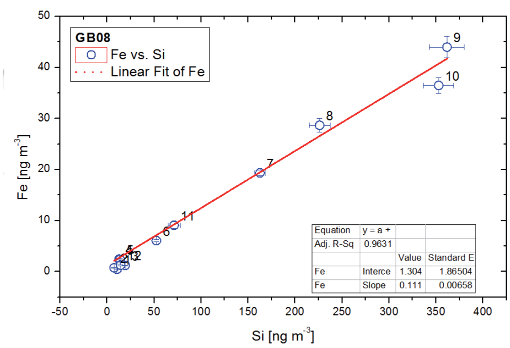

Fig. 2. Scatterplot of the concentration of Fe vs that of Si.

Linear fits of the scatterplots data are possible for most (9) of the above mentioned samples, with the restriction however of considering only the supermicrometric size range and avoiding in two cases one elemental pair. Figure 3 and figure 4 display one such case (GB07) where a linear fit for the Si, Fe pair is not possible. Three sets of values of, respectively, the Al/Si, the Fe/Si and the Ti/Si ratios are obtained for the above 9 samples. The mean values for Al/Si, Fe/Si and Ti/Si are, respectively: 0.50±0.015, 0.11±0.004, 0.013±0.0004. The corresponding standard deviations are: 0.043, 0.012, 0.0013. These results single out a dominant component in the supermicrometric size range, in the above set of samples. It should be noted that the selected range contains the highest-by-far concentration values and thus the most effective ones in the interaction with radiation.

Those cases excluded from the above treatment (e.g. Fe vs Si in GB07) clearly require a more complex treatment, as does, if necessary, the analysis of the intermediate and of the submicrometric modes.

TIME DEPENDENCE OF THE CRUSTAL COMPONENTS

Element Si, whose EMSD's are lognormally fitted in almost all samples and which has an important geochemical role, appears as the most convenient overall marker for any kind of crustal component. Figures 3, 4a and 4b display the time (sample number) dependence of Si intensity (parameter A) for the three size modes. The highest intensities (and thus the highest interaction with radiation) correspond to the set GB03 to GB10 and to a 32 days period. A quick reduction, by an order of magnitude, in the intensity A is observed (figure 3) in the supermicrometric mode, between samples GB10 and GB11. A similar effect is observed in the intermediate mode. The intensities of the intermediate and of the submicrometric mode are lower by almost one order of magnitude and, respectively, by almost two orders of magnitude than those of the supermicrometric mode, during the high intensity period (figures 4a, 4b).

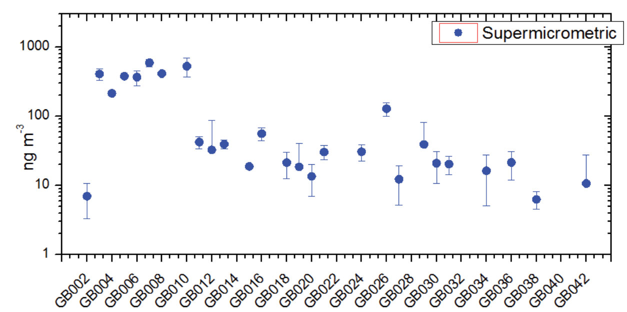

Fig. 3. Time dependence (sample number) of Si intensity.

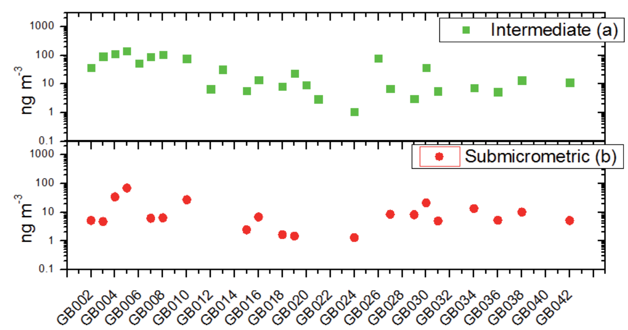

Fig. 4. Time dependence of Si in the intermediate and in the submicrometric mode.

CONCLUSIONS AND PROSPECTS

Satisfactory results for the composition of the crustal component were obtained by bivariate analysis of the scatterplots in high concentration samples and size modes. These results should be completed by considering elements Mg, K and Ca, which contain however an important contribution of marine origin. The preliminary evaluation and exclusion of this contribution is being carried on.

The interaction of aerosol with radiation must be evaluated starting from the composition data.

42 samples were collected in year 2011 and PIXE analysis was completed for those samples available to us.

The 2012 campaign will start soon.