

Introduction

Saharan dust is a main source of mineral nutrient input to the northern tropical Atlantic Ocean with dust deposition of about 20-100 gm⁻² per year (Mahowald et al., 1999). Particulate matter deposition on the ocean surface, affects its chemistry and thus the oceanic ecosystem therefore influencing the global carbon cycle. Amongst others bioavailable iron is crucial for marine bio-production. Although iron in Saharan dust is mostly less soluble at source regions, atmospheric processing during long-range transport can significantly change its solubility. In order to assess the role that mineral dust plays in marine biota, it is important to characterize and quantify its content.

Islands provide ideal locations for carrying out such investigations since there also lie within the ocean and thus experience the same dust deposition as the oceans. In this work, we report on the results of chemical characterization of marine aerosol particles containing amongst others sea salt and Saharan dust collected at the Cape Verde Atmospheric Observatory (CVAO, Fig. 1) in São Vicente, Cape Verde, west coast of Africa.

The samples were collected on top of a 30 m high tower which is situated at approx. 100 m offshore in order to minimize the effect of sea spray. Sampling was performed during intensive field campaigns lasting 4-6 weeks and also via continuous measurements from January 2007 to December 2010.

Sampling Site



Fig. 1. Cape Verde Atmospheric Observatory (CVAO) with a 30 m-tower for aerosol particle sampling, ~100 m offshore.

Experiment and Sampling

Aerosol sampling was done using a high volume DIGITEL DHA-80 sampler (PM₁₀-inlet), operated continuously in a 72 h sampling routine collecting particles on 150 mm quartz fiber filters (Fig. 2a).

During intensive campaigns: i) Five-stage BERNER impactor (Fig. 2b) with a PM₁₀ cutoff (0.05-10 µm size range) collecting size-resolved samples on aluminum and nuclepore foils and ii) Low volume DERENDA sampler (PM₁₀-inlet) collecting particles on 47 mm Teflon filters; were both operated in a 24 h sampling routine.

Filters were analyzed for, particle mass concentrations, organic and elemental carbon (OC/EC) and ions using ion chromatography. Nuclepore foils were analyzed for trace metals using TXRF. Teflon filters were leached with DI water (pH 5.5) via shaking for 2 hours and were analyzed for water soluble transition metal ions including Fe (III) and Fe (II) using an IC.

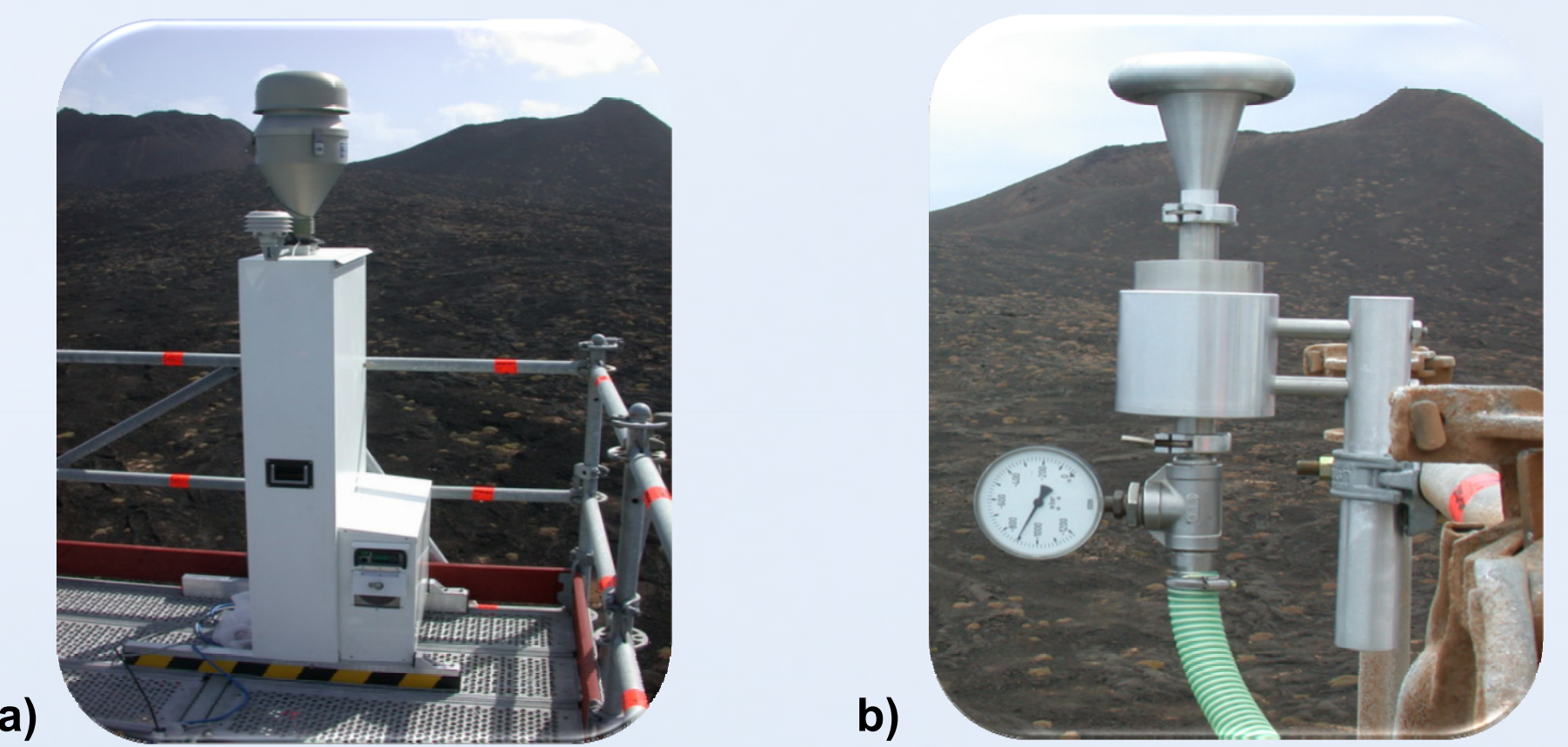


Fig. 2. a) DIGITEL DHA-80 high volume sampler with PM₁₀-inlet, with 500 l min⁻¹ sampling rate on 150 mm quartz fibre filters (Munktell MK 360); b) 5-stage BERNER impactor with 75 l min⁻¹, sampling rate on aluminium and Nuclepore® foil (Wicom Heppenheim GmbH, Germany), stage cut-offs: 0.05 - 0.14 - 0.42 - 1.2 - 3.5 - 10 µm.

Results

Seasonal trends of PM₁₀ mass concentrations was observed with highest concentrations observed during the winter months and minimal near ground concentrations during the summer months, Fig. 3 (Müller et al., 2010). High and low mass concentrations correlated with periods of Saharan dust storms and maritime air mass inflow, as illustrated on Fig. 3b) and 3c) via air mass back trajectories, respectively.

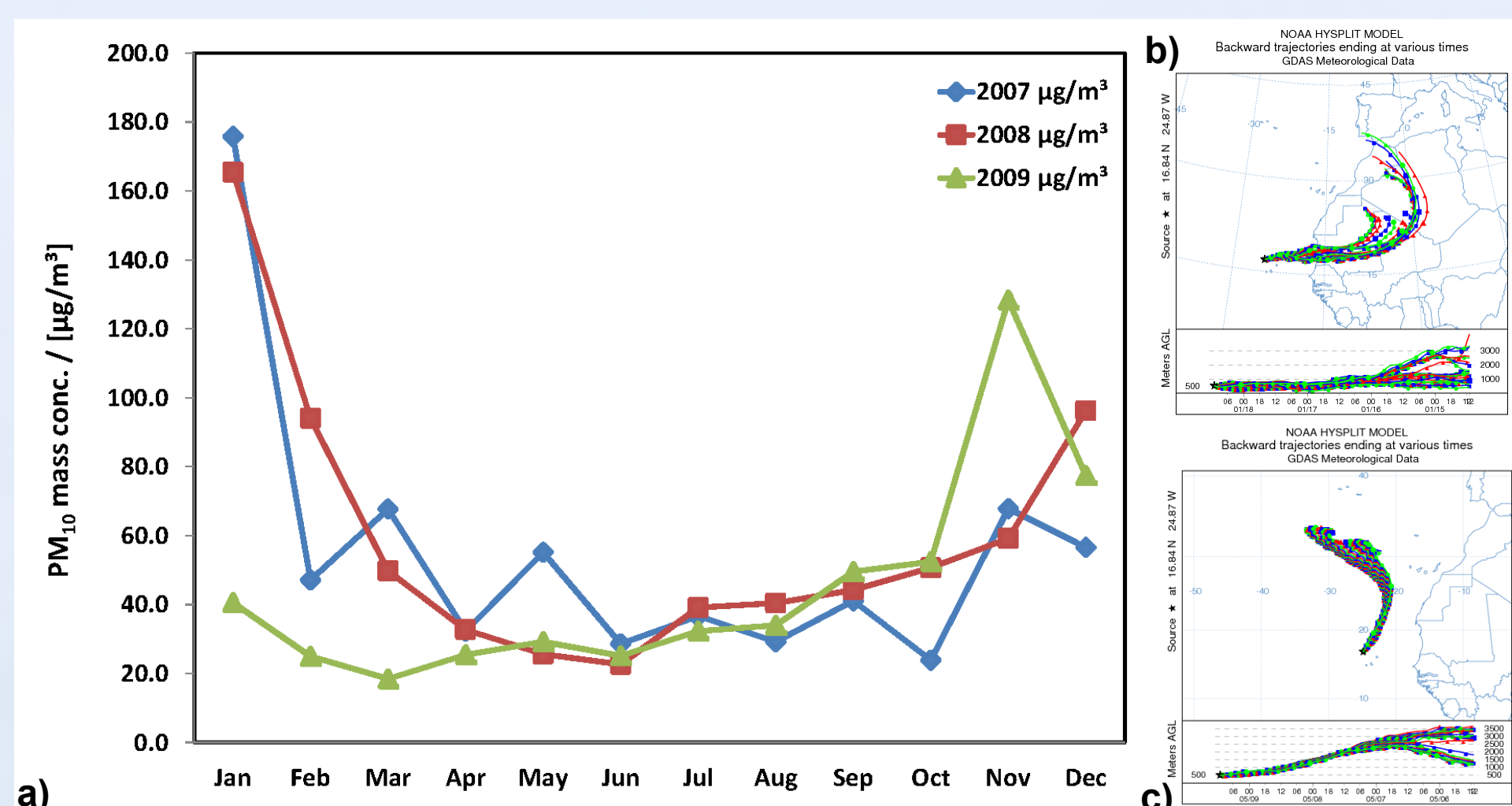


Fig. 3. a) Monthly mean mass concentration observed at CVAO from 2007 to 2009 showing seasonal trends. Air mass back trajectories showing typical b) Saharan dust storm and c) maritime air mass inflow at CVAO.

Trace metals were mainly of crustal origin and showed strong correlation with Saharan dust storms. The trace metals of crustal origin including, Fe, Ca, Ti, Mn, Si, Al were mostly found in the coarse mode PM as shown in Fig. 4a) for the case of iron during the winter 2008 field campaign.

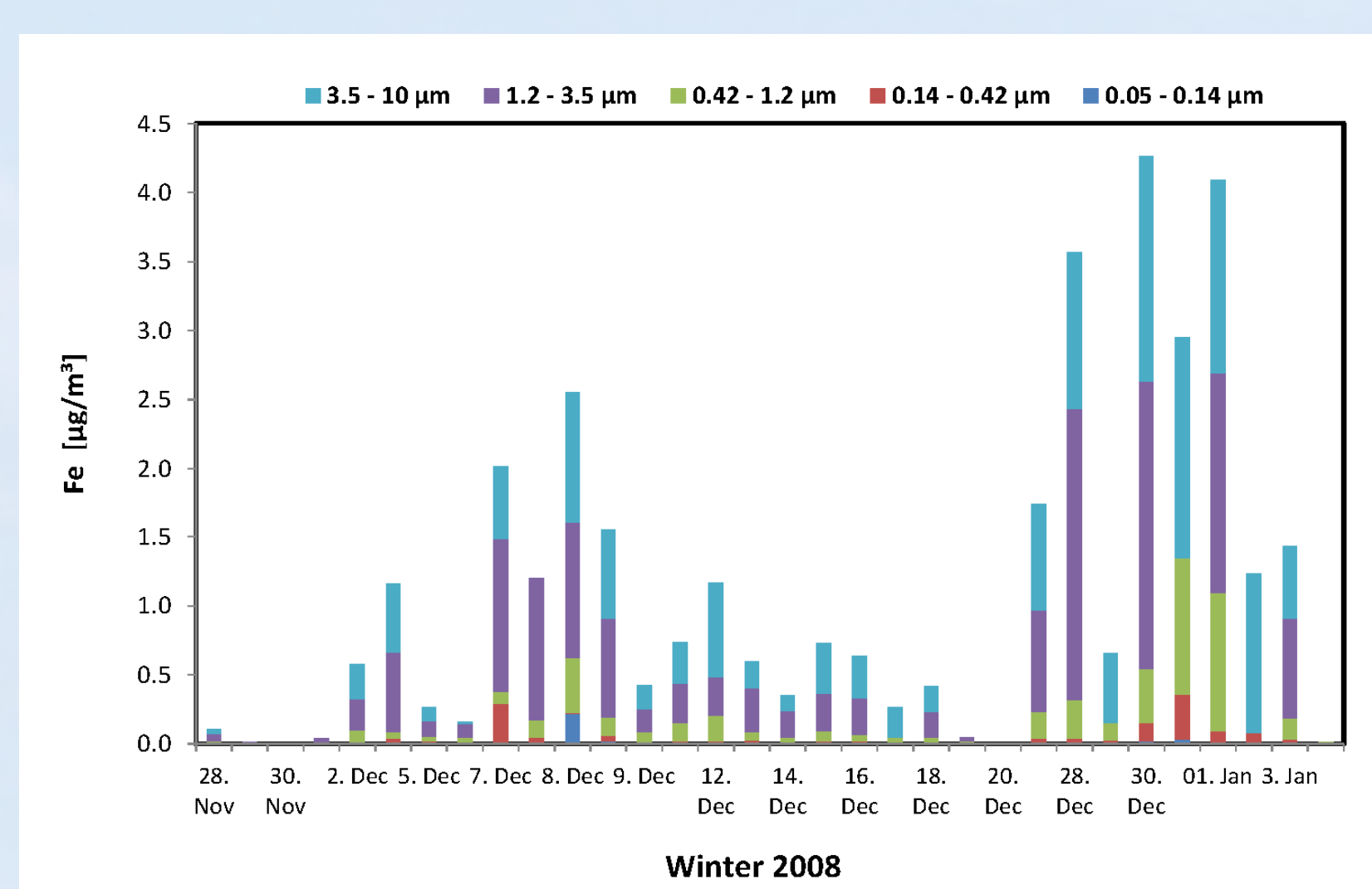


Fig. 4a). Size distribution of iron as marker for mineral dust showing occurrence in mainly the coarse mode PM.

The composition of the total identified PM₁₀ mass showed significant differences between low dust (Fig. 5a) and high dust periods (Fig. 5b). Typically, ions contributed about 55% to the PM₁₀ mass but decreased to a minimum of about 7% during dust episodes. OC and EC were found in very low concentrations except during dust events where the concentration increase by about a factor of five due to continental air mass influence. Fig. 5 shows the different compositions during the two situations.

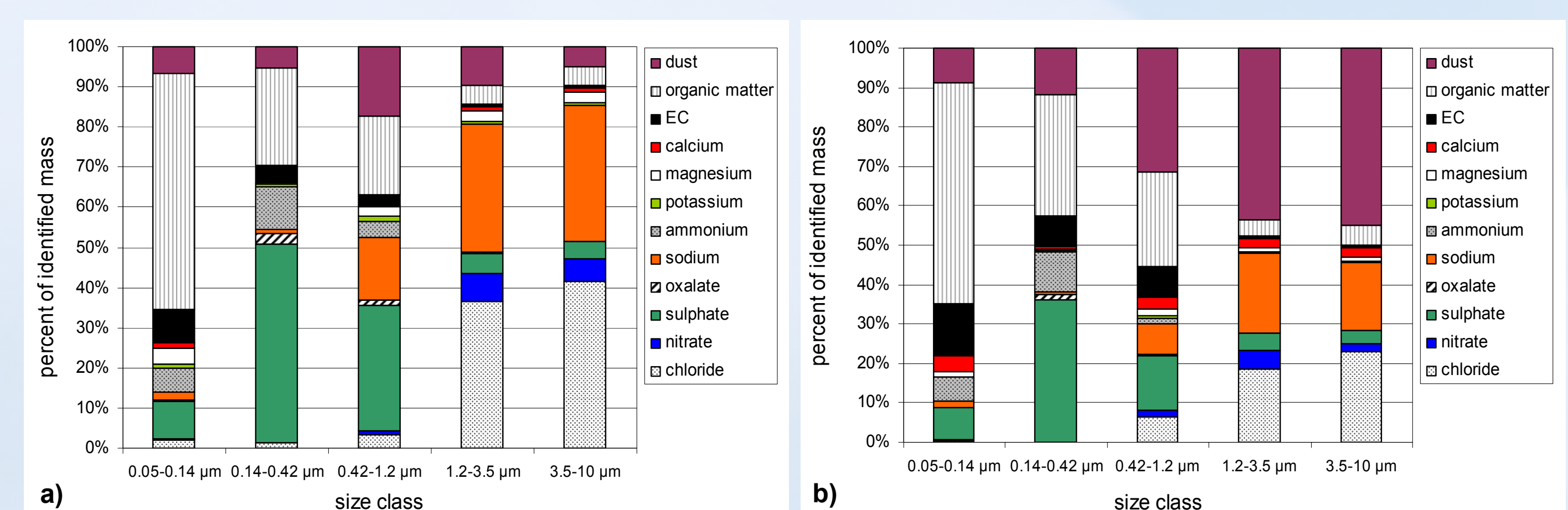


Fig. 5. Concentrations of ions during low dust (a) and high dust events (b) from BERNER samples (2007).

Water soluble iron was predominantly observed in the Fe (III) state. The total iron concentrations showed more or less an anti-correlation with lower water soluble iron concentrations observed during days of high total iron concentrations. Figures 6 shows this trend during both 2011 and 2012 winter campaigns, with iron solubility ranging between 0.01 to 0.7 wt.-%.

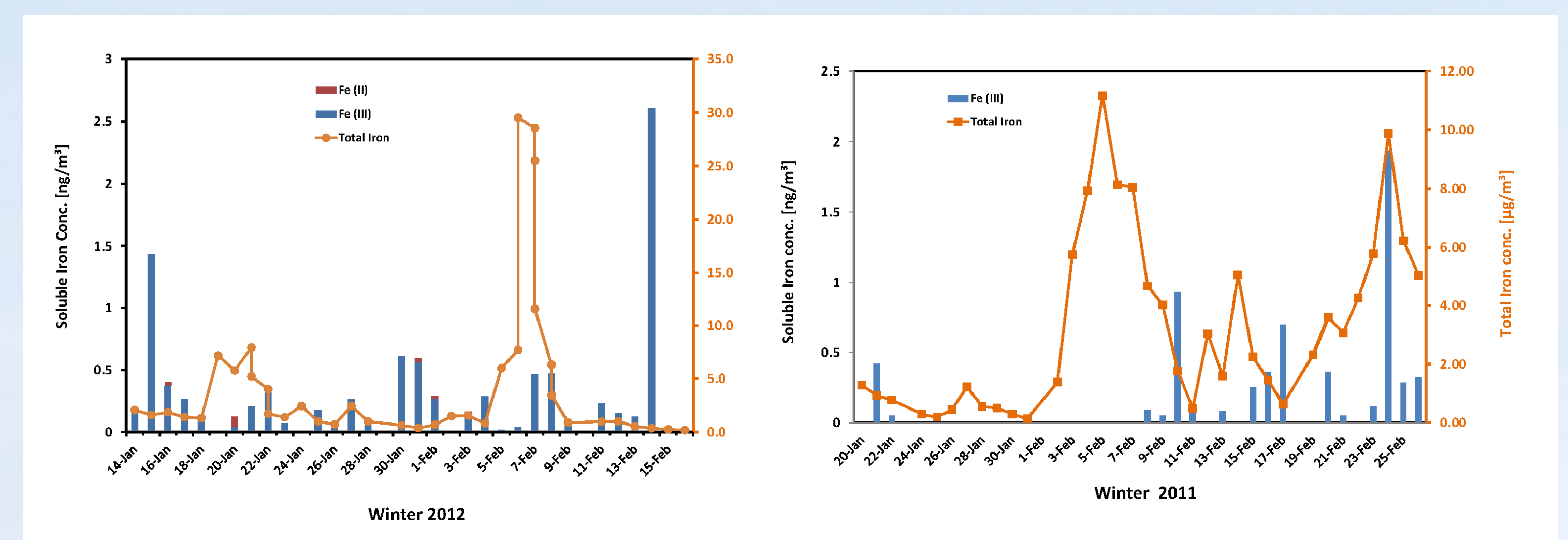


Fig. 6. Total and water soluble iron concentrations during two winter campaigns showing lower iron solubility during dust events.

Summary

The particle analysis results show a distinction between dust and low dust events. Most high dust events occur during the winter months with elevated mass concentrations in the coarse mode. Water soluble iron concentrations did not correlate with high dust loadings. Iron solubility varied between 0.01 to 0.7 wt.-% with lower solubility mostly observed during dust storms.

Acknowledgement

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References

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