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New insights on dust particles in Greenland ice cores combining state-of-the-art methods

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Aerosol-related impurities trapped in ice cores can supply important insights into the mechanics of our climate system. Mineral dust particles can provide information on past atmospheric transport and ice sheet size. This information is encoded in the geochemical composition and size of the dust particles: Local dust sources are characterised by large particles. As a prominent example, changes in dust particle sizes in the RECAP ice core from the Renland ice cap (East Greenland) have been shown to reflect smaller ice cap extent during interglacial periods [1]. To better understand dust chemistry and size changes at high resolution, we applied several state-of-the-art analytical methods to samples of the RECAP and EGRIP ice cores from East Greenland: Cryo-Raman spectroscopy, Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) 2D mapping, coulter counter (CC), time-of-flight single particle analysis (SP ICP-TOFMS), and Low-Background Instrumental Neutron Activation Analysis (LB-INAA). We show that high-resolution LA-ICP-MS maps of Na, Al, Mg, and Fe, in accordance with Raman spectroscopy data from the same samples, reveal the clustering of particles in the microstructure and a species-dependent preferred localisation. Subsequent measurements, taken where possible on the same samples, provide new insoluble particle size and concentration data (CC) and further in-depth elemental characterisation of the dust particles (cryo-Raman, SP ICP-TOFMS, LB-INAA). We can thus reveal changes in size and composition of the dust particles between the Holocene and the last glacial period, as well as within the last glacial. We further introduce a new approach to estimating particle sizes by utilising previously gathered data, exploiting SP analyses' vast, largely untapped potential for ice core science. The know-how in combining these different state-of-the-art methods and their insight into high-resolution dust chemistry and size will also provide important assistance for interpreting the dust signal stored in the upcoming deepest ice of the Beyond EPICA – Oldest Ice Core. Work performed in the framework of the Arctic Research Program of Italy (project PRA2021-0009 "Abrupt climate change and Greenlandice cover in a high-resolution ice

core record").

[1] Simonsen, M.F., Baccolo, G., Blunier, T. *et al.* East Greenland ice core dust record reveals timing of Greenland ice sheet advance and retreat. *Nat Commun* **10**, 4494 (2019). https://doi.org/10.1038/s41467-019-12546-2