Improvement of the dielectric tensor measurement as a method to measure density, 3D porous structure and crystal orientation fabric of ice cores: realization of high spatial resolution measurement and its impacts

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Major physical properties of ice cores include (i) densification from snow, firn to ice, and (ii) evolution of 3D porous structure composed of ice matrix and porous space. In addition, (iii) crystal orientation fabric (COF) is an important property to reveal degree of deformability (or viscosity) of polycrystalline ice. These three items are measurable with a method Dielectric Tensor Measurement (hereinafter, DTM) for which we use millimeter wave open resonators (Fujita et al. 2009, 2016, Saruya et al., 2021, 2022). The method has many advantageous conditions: (i) non-destructive, (ii) high-spatial resolution (a cylinder volume with ~15mm in diameter), (iii) continuous, (iv) rapid, and (v) safe. The authors have developed the DTM method of ice core analyses for the tentorial values of relative permittivity. We established a system to measure thick sections with thickness range from 5 mm to 70 mm with a diameter of about 15 mm, by a new design of the open resonator. In addition, based on this improvement, we realized common use of samples for DTM and Continuous Flow Analysis (CFA); CFA is the modern and major analytical method for ice cores to analyze major elements, water stable isotope ratio, dusts, gas components and so on with high-spatial resolution, continuously and rapidly. For measurements on density, anisotropy of the 3D porous structure, or crystal orientation fabrics, we can acquire basic physical property information of ice cores very efficiently compared with any conventional methods for these. In addition, because sample sticks can be common with CFA, we can reduce both ice core consumption and preparation work (cutting, microtoming and/or ice core management work). Because both CFA and the DTM use common ice samples, we can maximize information extraction from precious ice cores, making synergistic effects between multiple kinds of data. The DTM can be one of routine methods for future studies of ice cores. We can enhance better understanding the physical structures and deformation regimes within polar ice sheets and glaciers.

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